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Calibration Status and

Plans for the HST Scientific Instruments

Version 2.0
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CALIBRATION STATUS AND PLANS FOR THE HST SCIENTIFIC INSTRUMENTS

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1. INTRODUCTION

The main purpose of the HST calibration program is to convert the instrumental units of the telemetered data to physical units with the precision required to properly infer scientific conclusions. Another goal is to develope procedures that improve the operational efficiency of the observatory. These efforts are constrained by a sensible allocation of spacecraft time and by the resources required to analyze the calibration data.

The combination of spherical aberration with the instabilities that have been observed in most of the Scientific Instruments (SIs) has delayed the development of techniques to remove the instrumental signatures and quantitatively calibrate the SIs. With the completion of the Science Verification period and Cycle 1, the Instrument Development Teams (IDTs) have completed their formal reports on the SIs and have turned over responsibility for maintaining and improving calibration of the instruments and the telescope (OTA) to the Telescope and Instruments Branch (TIB) of the STScI.

Since the actual HST science data started to emerge from the Routine Science Data Processing (RSDP) pipeline at the STScI (see Appendix), both the pipeline software and the quality of the calibration reference files have been continously upgraded. In order for the early GTO/GOs to determine exactly what improvements are available for the reprocessing of a particular observation, a detailed history of all changes would be needed in an on-line data base. In view of this plethora of RSDP improvements, the STScI has started to reprocess all science observations obtained before 1992 Feb 10, when version 28.2 of the pipeline software was installed. The reprocessed data is available on request. For those GOs who want to be trained in reprocessing their own data, contact the USB.

This document summarizes the progress to date and presents the plans for future calibration efforts. In particular, Section 2 tabulates the status of the more important calibration parameters, Section 3 presents the abstracts for the Cycle 2 calibration proposals, and Section 4 is a bibliography of the TIB reports that detail the calibration results through May of 1992.

1.1 Documentation

The User Support Branch (USB) at the STScI can help members of the astronomical community in obtaining additional calibration related information, including copies of the Cycle 1 Calibration Plan, the STSDAS Calibration Guide, the Instrument Handbooks, the IDT final SV calibration reports, and copies of complete calibration proposals. Contact the USB secretary at (800)544-8125 or by e-mail at usb@.stsci.edu. In Europe, the European Coordinating Facility provides additional user support.

Instrument Science Reports (ISRs, see section 4) are available from the TIB secretary (Nancy Fulton) at (410)338-4955 or via e-mail at fulton@.stsci.edu.

For standard target files (see section 5) or digital SI calibration files from the Calibration Data Base System (CDBS), contact Daniel Golombek at (410)338-4974 or by e-mail at golombek@stsci.edu. Equivalently, call (410)338-1082 or e-mail to analysis@stsci.edu.

2. CALIBRATION ACCURACY: ACHIEVEMENTS AND GOALS

The following tables summarize the goals and current achievements for the major calibration quantities for each SI. The goals are optimistic predictions that assume solutions will be found to compensate for the various instabilities in the SIs. These are longterm goals and may not be reached during cycle 2.

The accuracy of the absolute flux standards that are observed to determine the SI absolute flux calibrations is about 3% in the visual longward of about 3400A, while the uncertainty in the standards increases to 10-15% in the far UV. Thus, the absolute flux accuracy goals for all SIs have these same limits and are not tabulated below. Relative photometic precision between objects in the same bandpass also limits the accuracy to which an absolute flux can be measured and is listed separately for each instrument.

Accuracies that are quoted below represent the precision of the calibrations themselves, which are based on many observation. Instrumental noise will also affect the precision of any result determined from applying the calibration to an individual science observation.

2.1 FGS

CALIBRATION	GOAL	ACHIEVED
Positional Astrometry (Relative to 10 reference stars)	3 mas	10 mas*
Single Star Apparent Diameter (in the 5-50 mas range)	3 mas	No data
Double Star Astrometry sep/pos-angle (for separations >15 mas)	3 mas/0.1deg	3 mas/0.1deg*
Relative Photometry	1%	10%*

* Based on preliminary engineering data.

2.2 FOC

These accuracies refer to a stable, routine situation. Unexpected instabilities are usually retroactively compensated by dedicated calibrations. The geometric stability of the FOC is 0.2 degree in rotation and 0.2% in X and Y for the F/96 mode, while the F/48 is only stable to 1 degree in rotation, 1% in X, and 0.5% in Y.

CALIBRATION	F/96 GOAL	ACHIEVED	F/48 GOAL	ACHIEVED
Dark Count	5%	-50% to +100%	5%	-50% to +100%
Aperture Alignment	0.1"	0.5"	0.1"	0.5"
Flat Field	5%	5%	5%	5%
Plate Scale	0.5%	0.24%	0.5%	0.16%
Geometric Correction central 512	0.5px	0.5px	0.5px	0.5px
outer area	1.0px	1-1.5px	1.0px	1px
Relative Photometry	10%	20%	10%	unknown
Absolute Photometry	~15%	~25%	~15%	unknown
Slit Spectrograph	N/A			
External Wavelength			30km/s	100km/s
Relative Spectrophotometry (Extended Sources)			20%	-50% to +100%
Objective Prism Spectrophotometry	25-40%	50%	25-50%	unknown

For a discussion of the linearity of the FOC, read the FOC ISR number 62.

2.3 FOS

There are three unexpected problems with the FOS, viz. the Geomagnetic Image Motion (GIM) in the red side digicon due to changes in the geomagnetic field around the orbit, the degradation of the red side sensitivity in the 1800-2100A region, and the decrease of the blue side sensitivity at all wavelengths. The red side GIM of the spectra on the diode array is compensated to the 0.25 diode precision by reading the spectrum frequently and adjusting the wavelengths in ground software. An onboard correction will soon be implemented. The high frequency components of the red side degradation are tracked by spectral flats that are obtained bi-monthly. The blue side losses are about 1% per month and seem to be continuous in time, which will permit a correction to the spectrophotometry that should be accurate to about 1%.

The preferred apertures are the circular 0.3, 0.5, and 1.0 arcsec, the slit, and the 4.3 arcsec square target acquisition aperture. The other apertures have uncertainties that may be a factor of 2 worse than those tabulated below for the preferred apertures. The photometric repeatability is a strong function of target acquisition accuracy and is quoted for the 4.3 arcsec aperture only.

CALIBRATION	**GOAL**	**ACHIEVED**
Internal wavelength	0.03 diode	0.25 diode
External wavelength	0.2 diode	0.4 diode
Paired pulse (linearity)	1%	1%
Spectral flat field	0.5-1%	2%
Relative spectrophotometry	1%	5%

2.4 GHRS

The GHRS calibration program has been hampered by the loss of side 1 and the hiatus of several months for side 2 observations.

CALIBRATION		**GOAL**	**ACHIEVED**
Internal wavelength (w/ cal lamp)		0.5 diode	0.5-1 diode
Internal wavelength (w/o cal lamp)		1 diode	1-2 diode
Paired pulse (linearity)		1%	1%
Spectral flat field		0.5%	0.5%
Relative spectrophotometry	LSA	1%	5%
	SSA	5%	15%

2.5 HSP

Dark current monitoring is done routinely for HSP.

CALIBRATION	GOAL	ACHIEVED
Relative photometry	1%	2%

2.6 WFPC

The photometric linearity of the CCD detectors is expected to be better than 1% (see the WFPC Instrument Handbook). The photometric repeatability is monitored monthly on WF2 and PC6 by BD+75 325 in the filters 230W, 289W, 336W, 439W, 555W, and 785LP. The changes vary from infinite in 230W to less than 2% at the longest wavelengths. The ability to correct for these changes with time and other effects is summarized below by the relative photometry entry.Imaging with the WFPC should not be attempted below 3000Å.

The flat fields for the following filters have the higher priority.

WF: F194W, F230W, F284W, F336W, F375N, F439W, F487N, F502N, F547M, F555W
F622W, F631N, F656N, F658N, F664N, F673N, F702W, F785LP, F889N

PC: F230W, F284W, F336W, F375N, F439W, F469N, F487N, F502N, F517N, F547M
F555W, F622W, F656N, F658N, F664N, F673N, F702W, F718M, F785LP, F889N

CALIBRATION	GOAL	ACHIEVED
Dark counts	5%	5%
Preflash level of 3-4 DN	0.5 DN	1 DN
Bias level of 300-500 DN	3 DN	3 DN
Flat field longward of 336W		
Small scale	2%	3%
Large scale	3%	10%
Relative Photometry longward of 336W	3%	5-10%
Plate scale	0.05%	0.05%
Residual geometric distortion w/i a chip	0.1 px	0.1wf/0.2pc

2.7 OTA

Any degradation of the primary and secondary mirror reflectivities are monitored with the FOC. The telescope focus is also monitored twice per year.

CALIBRATION	GOAL	ACHIEVED
OTA focus	5 microns	15 microns

3. CALIBRATION PROPOSALS FOR CYCLE 2

This section contains the abstracts for cycle 2 calibration proposals. Complete proposals can be provided on request (see section 1.1).

3.1 FGS

FGS 4043: FIFTEEN POINTS OF LIGHT

Calibrate the single star interferometric fringe (S-curve) across the field of view of the Astrometer FGS (FGS in bay No. 3). The calibration is at fifteen (15) different points within the field of view. At each point, multiple TRANSfer Mode observations of the fundamental reference star (Upgren 96) are taken through several filters. This calibration is essential for supporting observations of double and multiple stars of approved GO programs and also provides the fundamental POSition Mode observing centroiding corrections for both Fine Lock and Coarse Track.

FGS #tbd: SCALE CALIBRATION FOR TRANS MODE OBSERVATIONS OF BINARY AND MULTIPLE STARS

Calibrate the scale in different locations of the Astrometer FGS (FGS 3). This calibration is necessary to provide the actual separation among the components of binary and multiple stars. The method of calibration uses standard binary stars (ground-based calibrated with speckle interferometric techniques). Two reference binaries (to minimize systematic errors) are observed in ten different position within the FGS field of view. This calibration is essential, because POS mode astrometry, which should provide scale and optical field angle distortions everywhere within the field of view, has been put on hold.

FGS #tbd: ANGULAR DIAMETER CALIBRATION OF STARS AND MINOR PLANETS

This calibration is the analogue of that devoted to the support of binary and multiple star observations and provides an absolute scale calibration for angular diameter observations. The thirty standard objects available are observed in only one location of the FGS 3 field of view.

FGS #tbd: EXPOSURE TIME CALIBRATION FOR OBSERVATIONS OF POINT LIKE SOURCES IN HIGH BACKGROUND FIELDS.

This calibration determines how much observing time is necessary for TRANS Mode measurements of point like sources embedded in high background fields, especially those which show small scale structures and/or strong gradients with respect to the 5" x 5" FGS aperture. Five targets are observed in two different orientations and in only one location of the FGS 3 field of view. This calibration also provides the necessary data for exposure time calculation of POSition Mode observations in the same fields for parallax determinations.

3.2 FOC

FOC 4195: F/96 DETECTOR FOCUS - TO REPLACE OLD PROPOSAL

The purpose of this proposal is to verify the F/96 intensifier first stage focus. A standard HST calibration target field (NGC 6205) will be imaged at five different focus settings. The best focus will be determined by assessment of FWHM of star in each image. This proposal is intended to be run every 12 months to monitor the detector focus.

FOC 4196: F/48 DETECTOR FOCUS - TO REPLACE OLD PROPOSAL

This proposal will take observations of a standard HST calibration target field (NGC 6205) at five different settings of the F/48 intensifier first stage focus. A prism image allows discrimination between the red and uv. The observations will assist in determining the F/48 intensifier best focus.

FOC XXXX: F/96 AND F/48 OPTICAL FOCUS - NEW

The objective of this test is to determine the optimum setting of the FOC refocusing mechanism, using a standard HST calibration target field (NGC 6752). Two filters of different thickness are used. Each focus procedure will require 10 minutes per filter per mode of on-target time.

FOC 4101: F/96 & F/48 APERTURE LOCATION MONITORING - LEFT AS IT IS

Monitor the aperture locations over time with respect to the V2V3 axes. The verification of the aperture locations of the FOC f/48 and f/96 modes will be achieved by imaging a pair of astrometric stars (separation 10.5") in the full (512x1024 zoomed) format in both the f/48 and the f/96 cameras. Internal flats will be taken at the start of each observation to account for their geometric distortions.

FOC 4096: PLATE SCALE - TO REPLACE OLD PROPOSAL

The aim of these observations is to allow the platescale of the FOC f/48 and f/96 cameras to be monitored by imaging a pair of astrometric stars (separation ~10.5") in both the full (512x1024 zoomed) format and the centered (512x512 normal) format. A sequence of exposures will be obtained using each relay, at positions with known angular offsets. The offsets combined with the astrometric separation will serve unambiguously define the platescale for both relays. The observations will be analyzed off-line using CDBS, and the analysis will be used to update the FOC reference files in SOGS. Run this proposal at intervals of 4-6 months until such time as it is clearly no longer required.

FOC 4049: F/48 IMAGE STABILITY MONITORING - AS IT IS

This is an FOC engineering program needed to monitor the FOC/48 image stability after the introduction of the NEW Hold Mode: EHT Heater Power has been increased from 14 to 22 WATT. At the same time the Instrument WARM-up time was reduced from 3 hours to 3 min. The effects of the REDUCED Warm-up time on the image stability of the F/48 detector will be investigated.

FOC 4050: F/96 IMAGE STABILITY MONITORING - AS IT IS

This is an FOC engineering program needed to monitor the FOC/96 image stability after the introduction of the NEW Hold Mode: EHT Heater Power has been increased from 14 to 22 WATT. At the same time the Instrument WARM-up time was reduced from 3 hours to 3 min. The effects of the REDUCED Warm-up time on the image stability of the F/96 detector will be investigated.

FOC 2811: RELATIVE DQE CALIBRATION (FLAT FIELDS)- LEFT AS IT IS

The relative pixel-to-pixel response at UV wavelengths of the FOC over the entire field of view will be measured using a selected region of the Orion Nebula for the purposes of flat field illumination. This observation is a follow on to the 3160 FOC SV proposal which observed a region of the Orion Nebula for the purposes of determining full format flat fields. This proposal contines along the same lines by carrying out a similar observing program for the normal (512x512) format for both F/48 and F/96 to obtain higher signal-to-noise and higher resolution flat fields.

FOC XXXX: EXPLORATORY UV RELATIVE DQE - NEW

We will be attempting to obtain future UV flat fields at other wavelengths by the same means used to obtain the current ones (see ISR FOC-060). Although it is possible to estimate the count rates that will be observed from published data and current throughput paramters for the FOC, there is some uncertainty in the expected count rates. Since these flat field observing programs are quite time consuming, it would be prudent to make quick checks of the actual count rates with short test exposures. This proposal does that by observing the areas of the Orion Nebula that we expect to use with the filters that will be used. The count rate checks will all be taken with smaller formats than the intended future flat fields so that more accurate count rates can be measured if they are higher than expected. Each area observed will have one short full format exposure taken if it has not been observed in the past to see if there are stars or other features that may pose problems for future proposals.

FOC 2808: ABSOLUTE SENSITIVITY (F/96 RELAY)- TO REPLACE OLD PROPOSAL

The aim of this proposal is to repeat selected measurements of the f/96 DQE that have been measured in the past to confirm the expected DQE. The proposal consists of exposures of UV spectrophotometric standard stars for 5 filter combinations used in the previous

Absolute DQE exposures. The filter combinations will span the range of usable wavelengths of the f/96 camera (excluding those wavelengths already being monitored by the ongoing UV througput monitoring observations). For one filter combination the observations will be made for 3 different formats to verify format-independence of the response. Any significant discrepancies will result in more extensive followup observations so that the DQE curve for the f/96 camera can be appropriately updated. An interactive acquisition will be needed to center the image of the standard star.

FOC XXXX: F/48 ABSOLUTE DQE - NEW PROPOSAL

The absolute DQE for the f/48 camera has not yet been directly measured in orbit. This has been in part due to the absence of faint enough standards. This proposal will attempt to correct this deficiency by observations of UV standard stars with combinations of filters and small formats to achieve count rates that are not seriously nonlinear. Because of the use of small formats, interactive acquisitions will be required as well as special commanding for nonstandard formats. Internal LED exposures will also be necessary to geometrically calibrate the nonstandard format and to tie its absolute response to those of other formats (there is a significant format- dependent response variation for f/48).

FOC 2920: F/96 POINT SPREAD FUNCTION - TO REPLACE OLD PROPOSAL

The aim is to obtain ST/FOC instrumental point spread functions (PSFs) to facilitate the restoration of science data obtained through the f/96 relay. The structure of the PSF has to be measured with high photometric accuracy, otherwise it is not possible to discriminate the fine structure present in the PSF, from fine structure that may be intrinsic to the astronomical object itself.

FOC XXXX: F/48 POINT SPREAD FUNCTION - NEW

The aim is to obtain ST/FOC instrumental point spread functions (PSFs) to facilitate the restoration of science data obtained through the f/48 optical relay. The structure of the PSF has to be measured with high photometric accuracy, otherwise it is not possible to discriminate the fine structure present in the PSF, from fine structure that may be intrinsic to the astronomical object itself.

FOC 2816: SLIT FINE ALIGNMENT - TO REPLACE OLD PROPOSAL

Verify the accuracy of the F/48 spectrograph slit location. Procedure for slit location is to do a spatial scan with a standard astrometric star across the coarse position of the slit. Raster steps should be in intervals of 0.15".

FOC XXXX: OBJECTIVE PRISM - TO REPLACE OLD PROPOSAL

The aim of this proposal is to wavelength calibrate the objective prisms of the F/96 and F/48 relays, and to photometrically calibrate the F/48 prisms. An emission-line star will be observed using the four main prisms to refine the wavelength calibration obtained for the F/96 prisms in SV, and to calibrate the F/48 prisms for the first time. The photometric calibration of the F/48 prisms will be accomplished using spectrophotometric standard stars.

3.3 FOS

FOS 4059: ABSOLUTE PHOTOMETRY MONITOR

A calibration will be performed to determine the absolute sensitivity of the FOS detectors in each reasonable detector-grating combination (a total of 11). Five spectrophotometric standard stars BD+75d325, BD+28D4211, G191B2B, HZ44, and BD+33d2642 are on the target list. The stars chosen cover a range of magnitudes, and will also be used to verify the laboratory paired-pulse correction.

FOS 4097: LOCATION OF SPECTRA: Y-BASE MAPS

Locations of spectra are measured in OV twice and in SV 7 times (once with a measurement in all apertures at two grating settings plus all grating settings in two apertures, and 6 times with one aperture at all grating settings). In cycle 2 we will measure the locations of spectra for the 0.3" aperture at all grating settings once every 3 months to verify repeatability and to measure any long-term drift. This test has the highest priority because our ability to acquire spectra depends on our knowledge of Y_Base balues. Total spacecraft time is 1.9 hours of NON-PRIME time.

FOS 4098: DISCRIMINATOR TEST

The optimal discriminator settings were determined in OV. Because both the noise and gain are known to be temperature sensitive, some fraction of the channels may experience a change in their optimal discriminator settings on orbit. The discriminator/noise test is done once in cycle 2 to verify the stability of those settingxs. The FOS high voltage will be brought to approximately one-half the nominal operating voltage (12750 KV), with the REFDAC=250 and the trim focus current at 0. A 60s wait will allow the high voltage to stabilize. The command block YTDN will be run, with the INTFLAT as the source. Total time is 3.0 hours NON-PRIME.

FOS 4099: CYCLE-2 FOCUS, X-PITCH, AND Y-PITCH

After warm-up to the nominal high voltage, the trim current is set to zero, and the HV is set to a lower value. Spectra are then obtained with the 0.1-PAIR aperture, G190H, and the Pt-Ne lamp. The high-voltage is varied in 200 volt increments +/- 600 volts from the nominal setting with spectra taken at each setting to determine optimal focus. Once a optimal HV setting is determined, a series of spectra at three different X-Bases will be made to determine the corresponding X-Pitch. Additionally, measurements with the TALEDs through the 0.1-Pair aperture will be used to determine Y-Pitch. This program may result in an instruction flow change to the detector high voltage setting, the x-pitch value, the y-pitch value.

FOS 4123: SPECTRAL FLAT FIELDS MONITOR, REVISED

Obtain spectra of standard stars with relatively smooth continua, on a regular basis to track the time-dependence of flat-field structure of the FOS Red detector on the G190H, G270H, and G160L gratings. Spectra will be obtained in both the 4.3 aperture and the slit, since the flat- field structure is dependent on aperture size.

FOS 2819: DARK COUNT

Measurements of the instrumental background (dark) will be obtained as internal observations with the FOS. The exposures will be performed in pairs: the first of each pair with REJLIM set to default (no rejection) and the second with REJLIM set at a specified value, in order to determine the pulse-height distribution of background particle-induced events.

FOS 2820: WAVELENGTH CALIBRATION: INTERNAL/EXTERNAL OFFSETS

Offsets between internal and external wavelength scales will be measured for 3 gratings on the blue side and for 4 gratings on the red side. This test will be performed using the 0.3" aperture and one external source. Derived offsets can be applied to the polynomial fit of pixel number versus wavelength determined from the lines in the internal Pt/Cr-Ne lamp. Internal sources make up a small fraction of the exposure time and must be acquired at the same time as the external sources, so they can NOT be scheduled as parallel observations.

FOS 2824: POLARIMETRIC CALIBRATION

SV-calibrated combinations of detector, disperser, and waveplate that are now likely to be used for polarimetry will be re-measured. Y-bases and wavelength scales for these combinations will be re-calibrated. Further, with the implementation of the onboard GIM correction, red side polarimetry is feasible. Red side polarimetry Y-base, wavelength scale, flat field, and absolute calibration observations will be obtained for the useful modes.

FOS #tbd SPECTRAL FLAT FIELDS

Some FOS detector/disperser combinations have shown temporal variations in their flat field structure during SV and Cycle 1. This set of observations will produce additional flat field calibrations appropriate to the Cycle 2 time period. At one epoch during Cycle 2, high S/N spectra are obtained for G191B2B, which has a relatively featureless spectrum and which has been the primary target for earlier flat field observations. Observations are made through both the 4.3 arcsec square and the 0.25x2.0 arcsec slit apertures with all detector/ disperser combinations, except those that are to be monitored on a bi-monthly basis in companion proposal 4123, "FOS Spectral Flat Fields Monitor, Revised."

FOS #tbd: INTERNAL WAVELENGTH CALIBRATION

Since the internal wavelength calibration exposures (WAVECALS) have been removed from most of the cycle 2 calibration programs, this separate proposal is needed to monitor the stability of the FOS wavelength scale. All standard gratings are used with the 0.3"circle and either the 0.1" or 0.25" paired apertures. The WAVECAL lamp has a fairly constant output, so that these data are a secondary monitor of any changes in the FOS internal sensitivity. The program can be scheduled as a parallel observation and should be repeated every 2 months.

FOS 4211: APERTURE THROUGHPUT AND BLUE-TO-RED-SIDE OFFSET

Part I is a check of the small aperture transmissions that were determined in cycle 1 for the PRISM, G190H, and G160L in the 0.3, 0.5, 1.0, 2.5x2.0 (slit), and 4.3 arcsec apertures. A four stage peakup of the standard star should provide excellent centering in the small apertures. This program is the first check on the these small aperture transmissions relative to the 4.3 aperture since the execution of the SV proposal (3106) that determined the ratios. If the transmissions do not repeat to few percent, then a regular monitoring of the small apertures is required to determine the statistical uncertainty in the photometric repeatablity of small aperture FOS spectra.

Part II is a measurement of the offset of the blue side apertures with respect to the red side. Since the peakup on the first side provides a precisely centered target, the switch to the second side followed by the peakup in the 0.3 aperture determines an accurate measure of the separation of the blue and red side apertures in the focal plane with no extra expenditure of observing time.

3.4 GHRS

GHRS 2851: PULSE HEIGHT ANALYSIS (PHA)

Perform a pulse height analysis to determine individual diode response as a function of threshold for both HRS detectors. Based on this evaluation new thresholds may be determined for optimal HRS operation. This test is run once during the year. Also included is one ion test which is a PHA of twice normal threshold to look for ion events, which accelerate positive ions backwards up the 22 kV potential of the tube, liberate electrons from the phocathode, and produce events of twice normal energy.

GHRS 2852: THRESHOLD ADJUSTMENT TEST

This test determines the optimal, non-standard discriminator thresholds for the few anomalous channels on each HRS detector. A 15 second flat field observation followed by a 210 second dark count is performed at each of 10 discriminator threshold values for each detector. The result of the test will be the optimal threshold values to be entered into the PDB.

GHRS 4012: DARK COUNT STATISTICS FOR GHRS DETECTORS

The proposed observations will obtain the statistical data needed to plan an operational strategy for observing faint targets with the GHRS. The proposed test involves only the use of Side 2, since only this side of the GHRS can benefit from the results of this test at the present time. Because of the loss of the GHRS low-resolution mode (G140L), many observing programs that had originally specified G140L have been changed to use G160M. Hence, the problem of reducing the GHRS dark-count becomes even more acute. The proposed tests should provide the information needed to evaluate how much the dark-count can be reduced by the appropriate operational strategy

GHRS 4065: DARK NOISE MONITORING HRS

CYCLE 2 test for routine monitoring of detector dark noise. This proposal provides the primary means of checking on health of the GHRS detector systems through frequent monitoring of the background count rate.

GHRS 4066: ECHELLE SPECTRAL LAMP MINI-FUNCTIONAL TEST

The spectral lamp test for Echelle B is an internal test which makes measurements of the wavelength lamp SC2 and measures the carrousel function, Y deflections, resolving power, sensitivity, and scattered light. This test will be run every 4 months.

GHRS 4067: 1ST ORDER GRATING SPECTRAL LAMP TEST

The spectral cal lamp mini-functional test for the first order gratings is an internal test which makes measurements of the lamp (SC2) and determines the carrousel function, Y deflections, resolving power, sensitivity, scattered light, and the wavelength calibration dispersion constants

GHRS 4068: DETECTOR CALIBRATIONS

This proposal defines 2 sets of standard detector tests; a very short set will be run 4 times per year for each detector, and a longer set will be run as needed for each detector.

GHRS 4124: SENSITIVITY MONITOR

This proposal defines a long term sensitivity monitoring program for the Goddard High Resolution Spectrograph using two UV standard stars, BD+28d4211 and mu Columbae. BD+28d4211 is the long term standard and allows cross-calibration with FOS. Mu Col is observed with the LSA and SSA. The medium resolution gratings measure mu Col through the LSA and SSA. Observations are made at intervals of 100A across the range of each grating. For the echelle, OSCAN observations measure the sensitivity near the the blaze peak. The setup for the echelle is the same as that used in SV to maintain traceability to the original calibrations. WSCAN observations scan across m=20 in ECH-B. This test should be run approximately three times per year to monitor the long term photometric stability of the GHRS.

GHRS #tbd: VERIFICATION OF LSA RETURN TO BRIGHTEST

Flight software 4.0 release will include an important new capability for the GHRS -- return to brightest point following a spiral search. This target acquisition mode will become the default for most observations. This test is to acquire a standard calibration star using the previous standard mode and to record a confirmation image. Following a slight repositioning of the telescope to mimic typical initial pointing errors, perform a return to brightest based spiral search and obtain another confirmation image. This exercise of the new flight software will directly test whether the basic procedure works. Execution time should be two orbits or about one hour of charge.

GHRS #tbd: RELATIVE APERTURE FINE ALIGNMENTS AND VERIFICATION OF SSA PEAKUP.

Flight software 4.0 release will include an important new capability for the GHRS -- a real flux peakup algorithm for the Small Science Aperture. Exercise the new flight software capability and simultaneously derive new offset relations for the LSA and SSA. The LSA to SSA positions are uncertain at the level of a (few)x0.01 arcsec. This residual error can be efficiently determined once the SSA Peakup commanding is available. Blind offsets to the SSA will be performed after both N2 and A2 target acquisitions, followed by SSA Peakup spiral searches. Execution time should be two to four orbits, about 1-2 hours.

3.5 HSP

HSP 4209: SENSITIVITY TEST

This test provides long term detector sensitivity measurement for the 4 HSP IDT detectors. The test measures the sensitivity of the IDT's to light from two calibration targets. Two targets are chosen to establish a calibration link to existing HSP data. The program collects area scan data on both the finding aperture and a F240W aperture for the UV1 and VIS detectors, an F248M filter for the UV2 detector and for a F327M filter on the POL detector. Data will be collected every two months to provide a calibration of detector sensitivity as a function of time.

3.6 WFPC

WFPC 4109: RAPID INTERNAL MONITOR 1

Take repeated internal flats to test for contamination buildup on the optical surfaces or the reappearance of QEH. INTFLATS in F555W are obtained every 4 days in both WFC and PC to check for measles or daisies and to monitor scattered light.

WFPC 4140: RAPID INTERNAL MONITOR 2

Take repeated internal flats to test for contamination buildup on the optical surfaces or the reappearance of QEH. Sequential INTFLATS in F439W with PC are obtained every 7 days to check for QEH.

WFPC 4089: PC INTERNAL DELTA FLATS

Take internal flats periodically to permit the repair of external (earth-target) flat fields that

are effected by pixel dependent QE changes, which occur whenever the WF/PC is decontaminated. The internal flat lamp is useful with relatively wide filters in the red.
Filters used:
PC: F439W, F547M, F555W, F569W, F606W, F588N, F622W, F631N, F664N, F675W, F673N, F702W, F718M, F791W, F785LP, F725LP, F875M, F889N F850LP, and F1042M

WFPC 4091: WFC INTERNAL DELTA FLATS

Take internal flats periodically to permit the repair of external (earth-target) flat fields that are effected by pixel dependent QE changes, which occur whenever the WF/PC is decontaminated. The internal flat lamp is useful with relatively wide filters in the red.
Filters used:
WFC: F439W, F492M, F547M, F555W, F569W, F606W, F622W, F631N, F656N, F664N, F675W, F673N, F702W, F785LP, F814W, F875M, F889N, F1042M

WFPC #tbd: INTERNAL MONITOR PROPOSAL

Monitor darks, biases, and preflashes. This proposal also obtains internal alignment KSPOT images in both cameras, which provides a measure of mechanical and internal PSF stability. Only internal targets are used. The execution frequency is once per month, using parallel time.
WFPC #tbd: WFC Primary Flats 1
WFPC #tbd: WFC Primary Flats 2
WFPC #tbd: PC Primary Flats 1
WFPC #tbd: PC Primary Flats 2
WFPC #tbd: RECIPROCITY MONITOR

This program takes "uniformly illuminated" pictures of the earth to monitor the "reciprocity" effect observed in earth calib observations. The goals of this program are:
1. Watch for discrete changes in this behavior
2. Look for long term variability
3. Have before/after checks in place for decontaminations, safings, or UVflood.
This program will also build up a high quality flat field. The observations are done only with PC with a frequency of once every week. The sequence (during a single earth occultation) is: F517N+OPEN, F517N+F122M, F517N+OPEN

WFPC #tbd: NON-SV WFC FLATS 1

Take "uniform illuminated" pictures of the earth to obtain the "instrument signature" for flat field corrections. This proposal contains observations for WFC filters used by GOs and GTOs during Cycle 1 which were not included in the SV flat field program.
The camera - filter combinations in this proposal are:
WFC: F469N, F1042M, F1083N.
These WFC flats should not saturate on the bright earth.

WFPC #tbd: NON-SV WFC FLATS 2

Take "uniformly illuminated" pictures of the earth to obtain the "instrument signature" for flat field corrections. This series contains observations for the remainder of the WFC filters used by GOs and GTOs during Cycle 1 which were not included in the SV flat field program. The camera - filter combinations done in this proposal are:
WFC: F492M,F569W,F606W,F675W,F725LP,F791W,F814W,F850LP,F875M
(these are done in combination with F122M)
These flats are expected to saturate on the bright earth without a neutral density filter.
The following observations are also included with and without the F122M filter to permit correction:
F502N,F588N,F673N,F889N

WFPC #tbd: NON-SV PC FLATS 1

Take "uniformly illuminated" pictures of the earth to obtain the "instrument signature" for flat field corrections. This proposal contains observations for PC filters used by GOs and GTOs during Cycle 1 which were not included in the SV flat field program.
The camera - filter combinations are:
PC: F368M,F588N,F631N,F648M,F875M,F1042M
These are the PC flats which are not expected to saturate on the bright earth.

WFPC #tbd: NON-SV PC FLATS 2

Take "uniformly illuminated" pictures of the earth to obtain the "instrument signature" for flat field corrections. This series contains observations for the remainder of the PC filters used by GOs and GTOs during Cycle 1 which were not included in the SV flat field program.
The camera - filter combinations are:
PC: F569W, F606W, F675W, F725LP, F791W, F814W, F850LP
(these are done in combination with F122M)
These are the PC flats which are expected to saturate on the bright earth without a neutral density filter.
The following observations are also included to permit correction for the F122M filter:
F517N+F122M, F517N, F664N+F122M, F664N,
F718M+F122M, F718M, F875M+F122M, F875M

WFPC #tbd: PHOTOMETRIC CALIBRATION MONITOR

Monitor the QE of the WFC and the PC. Exposures in F230W, F284W, F336W, F439W, F555W, and F785LP in both WFC and PC are taken of a UV flux standard star once per month. Normally observations are obtained in FINE LOCK.

WFPC #tbd: Interchip Photometric Calibration

WFPC #tbd: LINEARITY CHECK

A series of pairs of exposures of increasing duration will be taken of a diffuse target (M-42) to establish the WF/PC light transfer characteristics. These data will be used to determine the linearity and instrument readout noise level for each CCD.

WFPC 4095: INTERNAL LAMP TEST

Determine the warm-up characteristics of the internal lamp with intflats for: WFC only: F606W, F675W, F814W, F785LP, F1042M for exposure times of .2, .3, .4, .5, .7, and 1.0 seconds

WFPC 3971: UV FLOOD

To achieve stable quantum efficiency performance for the overthinned areas of the CCDs, the chips must be flooded with ultraviolet light. This will produce a uniform quantum efficiency response over the entire CCD. The quantum efficiency stability is chiefly dependent on temperature. The exact amount of UV light required to eliminate quantum efficiency instability is determined by ground tests and SV data.

WFPC #tbd: FOUR CHIP UV CALIBRATION

Calibrate the QE of the WFC and PC in the ultraviolet (F194W, F230W, and F284W). This calibration is done for each CCD detector using exposures of a UV flux standard star and is intended for use only during a UV campaign.

WFPC #tbd: UV FLATS 1

Take "uniformly illuminated" pictures of the earth to obtain the "instrument signature" for flat field corrections for the UV filters. The camera - filter combinations done in this proposal are:
WFC: F194W, F230W, F284W
PC: F194W, F230W, F284W
This calibration should be part of each UV campaign.

WFPC #tbd: LIGHTPIPE THROUGHPUT TEST

This test is still in the process of being defined.

3.7 OTA

OTA 4152: FOC OBSERVATIONS TO MONITOR DESORPTION

Perform FOC observations through filter F486N in the F/96 mode to monitor focus stability of the HST OTA focal plane. This set of 4 images is obtained a total of three times with roughly 120 day spacings. The observations will provide data useful in assessing the HST OTA Focal plane desorption.

OTA 4153: FOC UV THROUGHPUT MONITORING

Image a UV standard in F/96 mode in order to monitor the UV throughput of the HST-FOC.

Data will be taken every 6-8 weeks.

4. INSTRUMENT SCIENCE REPORTS

The techical writeups of SI performance that are known as Instrument Science Reports (ISRs) are one of the most important products of the TIB. Although the ISRs dated after the HST launch in 90Apr are the most relevant, the pre-launch work is sometimes still definitive. See section 1.1 for availability. Any calibration, target acquisition, or other SI performance parameters of use in obtaining or analyzing HST data are documented in the most detail in this series of reports.

4.1 FGS

001 Space Telescope Motion Limitations for Fine Guidance Sensor Astronometry - A. Fresneau - 1/84
002 Effect of Guiding Errors on Astrometry - A. Fresneau - 1/84
003 Review of the Calibration Requirements A/I, Requested in Your Memo of February 9 - A. Fresneau - 2/84
004 Astronometry Error Sources and Calibration Requirements for FGS in Pointing and Astrometry Modes - A. Fresneau - 2/84
005 Proposals of Observations with the Space Telescope in the Domain of Astrometry - A. Fresneau - 1/85
006 Astrometric Data Calibration - A. Fresneau - 1/85
007 Stellar Diameter Measurements - A. Fresneau - 3/85
008 FGS Exposure Time Estimation - A. Fresneau - 3/85
009 Correction of FGS Encoder Errors - A. Fresneau - 5/85
010 Calibration of Interferometer Gains K0 and K1 - A. Fresneau - 3/86
011 S-Curve Calibration - A. Fresneau - 5/86
012 CDBS Table - M. Lattanzi - 5/90
013 Astrometry Pipeline Desing Document - L.G. Taff, B. Bucciarelli - 6/90
014 Review of Possible Causes of GFS Astrometry Errors - M. Lattanzi - 4/90
015 Recommendation for Guide Star Catalog Re-reduction - L.G. Taff - 9/89
016 Is A Simple OTA/FGS Optical Simulator Possible? - L.G. Taff, M.G. Lattanzi, S.T. Holfeltz, B. Bucciarelli - 8/91
017 Fine Guidance Sensor Report - M.G. Lattanzi, S.T. Holfeltz, L. G.Taff, 12/91
018 Data Smoothing and Double Star Data Reduction in the Transfer Function Mode Reduction Package, S.T. Holfeltz, B. Bucciarelli, M.G. Lattanzi, L.G. Taff, 12/91
019 The ST ScI Transfer Function Mode Data Reduction Package, M.G. Lattanzi, B. Bucciarelli, S.T. Holfeltz, L.G. Taff, 5/92

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002 FOC Intensity Transfer Function Preliminary Evaluation of Laboratory Calibration Data - C.A. Grady, M. Pelizzari, J.C. Blades, F. Paresce - 11/83
003 FOC-Spectral Data for Onboard Filters, Lamps & Mirrors - J.C. Blades, S. Ewald - 7/84

004 Analysis of FOC Fixed Pattern Noise - A. Pickles, J.C. Blades, J. Bohlin & F. Paresce - 10/84

005 FOC Response to Line Emission During the Optical Throughput Test at LMSC - F. Paresce - 2/85

006 The Effect of Visible Light Leaks in the Narrow Band FOC Filters: Possible Solutions - F. Paresce - 2/85

007-IFixed Pattern Noise in FOC Images I - J. Bohlin & J.C. Blades - 5/85

007-IIFixed Pattern Noise in FOC Images-II - J. Bohlin & J.C. Blades - 2/86

008 Geometric Correction of FOC Images - J. Bohlin & J.C. Blades - 5/85

009 The FOC Science Verification Plan and RSDP Processing - J.C. Blades - 1/86

010 Pattern Noise in the PFM1 and PFM4 Detectors - P. Greenfield - 1/86

011 Information Needed for FOC Calibration - D. Giaretta - 2/86

012 Creation of the First Relative DQE Calibration File for the PFM2 Detector of the FOC - J.N. Bohlin - 3/86

013 Expected Status of the FOC After Completion of SV - J.C. Blades - 2/86

014 FOC Mode II Target Acquisition - A. Nota, M. Miebach & J.C. Blades - 9/86

015 FOC Modes I and II Acquisition Capabilities for Moving Targets - J.C. Blades & A. Nota - 12/86

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017 Prelaunch Calibration Files for RSDP - P. Greenfield & D. Giaretta - 10/86

018 Preliminary Results of the Throughput Opical Test on the Faint Object Camera at LMSC in June 1986: Overall Average Detective Efficiency ofthe FOC & OTA Optical System in the Visible and Ultraviolet - F. ParesceY. Franke & N. Towers - 10/86

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020 Testing RSDP:I, D. Giaretta - 11/86

021 Comparative Timinings of Selected Routines in SDAS, IRAF, MIDAS and IDL - P. Greenfield & C. Heaps - 10/86

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025 (never completed)

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027 FOC Mode I Target Acquisition - A. Nota & J.C. Blades - 4/87

028 Initial Analysis of PFM1 Complex Mask Exposures - P.Greenfield, C. Heaps & D. Giaretta - 6/87

029 A Test of the Procedure of FOC Mode I Target Acquisition in OSS - A. Nota, O. Lupie & J.C. Blades - 7/87

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031 Testing of RSDP for FOC: I - C. Heaps - 12/87

032 FOC Mode III Target Acquisition, A. Nota and C. Blades - 2/88

033 Testing of RSDP for FOC: II - C. Heaps & Y. Frankel - 6/88

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036 Position Measurements of the New F/96 Fingers and F/48 Slit Notch - A. Nota - 12/88
037 Example of Calculation to Derive PDA Slit Center Coordinates from Measurements of PDA Slit Notch Coordinates - A. Nota & O. Lupie - 2/89
038 Ground-based Calibration of the FOC Objective Prism Facility - F. Paresce P. Greenfield - 3/89
039 FOC Flat Field Response - P. Greenfield - 6/89
040 A Verification Procedure for Mode I Target Acquisition - A. Nota & N. Towers - 6/89
041 GST-7 Test Report - G. Meylan - 10/89
042a The FOC Aperture File - A. Nota, O. Lupie & K. Clark
042b CALFOC Test - D.A. Baxter & G. Meylan - 2/90
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044 The FOCSIM User Manual - Y. Frankel & F. Paresce - 3/90
045 FOC Geometric Stability Tests - OV Part I - D. Baxter - 6/90
046 Long Term Geometric Stability - D. Baxter - 11/90
047 FOC Geometric Stability - OV Part II - D. Baxter - 11/90
048 Guide to FOC Exposure Catalog and Archiving Procedures (version 1.0) P. Greenfield - 12/90
049 (never completed)
050 UV Throughput Monitoring for the FOC During OV/SV, W. Sparks - 7/91
051 Suggested Changes to the RSDP Pipeline for FOC Data - P. Greenfield - 8/91
052 How to get the North-East orientation of an FOC frame, W. Hack - 12/91
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055 f/48 Detector Focus Adjustment, N. Towers, M. Miebach - 12/91
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057 The FOC Polarizing Filters, P. Hodge, 2/92
058 A Check for stability of the FOC apertures, W. Hack, A. Nota, 3/92
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060 FOC UV Flat Field Response, P. Greenfield, 5/92
061 Algorithms and Software used to process the Orion Flat-field Data, P. Greenfield, 5/92
062 Flatfield Linearity, R. I. Jedrzejewski, 5/92

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002 FOS Entrance Aperture Sizes - J. Wheatley, R.C. Bohlin & H. Ford- 10/83
003 Recent FOS Calibration at GSFC - J. Wheatley & R. Bohlin - 11/83
004 FOS Wavelength Calibration - J. Wheatley & R. Bohlin - 12/83
005 FOS-Scattered Red Light (Red Tube) - J. Koornneef- 1.84
006 FOS Flat Field Calibration (FOS Calibration #15) - D. Lindler & R. Bohlin - 3/84
007 FOS Scattered Light Measurements (Cal. Plan #128) - J. Wheatley & R Bohlin - 3/84

008 FOS Aperture Repeatability & Filter - Grating Wheel Repeatability - 5/84 (Calibration Plan 10C & 10D) - J. Wheatley, H. Ford & R. Bohlin
009 FOS Firmware Target Acquisition - H. Ford - 6/84
010 High Voltage Settle (FOS Calibration #08) - D. Lindler & R. Bohlin - 12/84
011 Scattered Light Background Perpendicular to the Dispersion - Preliminary Version (Calibration #19) - D. Lindler & R. Bohlin - 1/85
012 FOS Filter Grating Wheel Repeatability (Calibration Plan 10D) - G. Hartig, R. Bohlin, H. Ford & R. Harms - 12/84
013 Scattered Red Light - Preliminary Version (Calibration Plan 12A) - M. Sirk & R. Bohlin -
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017 Improvements in Filter/Grating Wheel Repeatability - G. Hartig - 5/85
018 FOS Line Widths 9FWHM) as a Function of Aperture Size - A. Kinney & H. Ford - 5/85
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021 LMSC NSSC-1 Target Acquisition Tests of Feb. 1985 - D. Lindler, A. Kinney & H. Ford - 9/85
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023 Mode 2 Target Acquisition: Binary Search Parameters, Oct. 1985 - A. Kinney & H. Ford - 10/85
024 Results of Binary Search Target Acquisition Tests of August, 1985 - A. Kinney & H. Ford - 11/85
025 FOS Linearity Corrections - Jan. 1986 - D. Lindler & R. Bohlin - 1/86
026 FOS Wavelength Calibration - Jan 1986 (Laboratory Calibration Plan 13b) M. Sirk & R. Bohlin - 1/86
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029 FOS Entrance Aperture Offsets (Calibration Plan 136) M. Sirk & R. Bohlin 5/86
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031 Commanding FOS Target Acquisition - T.M. Gasaway & A. Kinney - 6/86
032 An Automated Method for Computing Absolute Instrumental Sensitivity Curves for FOS: Results of Testing on IUE - D. Lindler & R. Bohlin - 8/86
033 Thermal Vac Measurements of the FOS Filter Grating Wheel Repeatability G. Hartig - 8/86
034 FOS Throughput Optical Test REsults - G. Hartig - 8/86
035 Results of TA Tests at LMSC: Feb. 1986 A. Kinney - 8/86
036 TV Monitoring of the F8 Detector Red Sensitivity (Test Segment MONTHLY) - G. Hartig- 8/86

037 Ambient QE Measurements of the FOS Red Side - G. Hartig - 10/86
038 FOS Wavelength Scale Below the Calibration Lamp Cutoff at 1239A (Lab. Calibration Plan 13B) - M. Sirk & R. Bohlin - 10/86
039 FOS Entrance Aperture Transmittance for Point Sources - G. Hartig - 11/86
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043 FOS Target Acquisition Cook Book - A. Kinney & R. Antonucci - 5/88
044 Limiting Accuracy of FOS Wavelengths Calibration - R. Bohlin, M. Sirk & G. Hartig - 10/87
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046 FOS Aperture Wheel Repeatability - R. Harms & R. Downes - 10/88
047 FOS Exposure Limits - G. Hartig - 10/88
048 FOS Wavelength Calibration Exposures - G. Hartig - 10/88
049 FOS Filter Grating Wheel Repeatability (Revisted) - G. Hartig - 10/88
050 FOS Discriminator Settings - R. Cohen, E. Beaver & D. Tudhope - 5/90
051 Dead and Noisy Diode Summary - R. Cohen - 4/89
052 Results of TA Related Tests - A. Kinney - 2/89
053 Laboratory Calibration of FOS Throughput - G. Hartig - 1/89
054 Revised FOS Wavelength Calibration - G.A. Kriss, W.P. Blair, & A.F. Davidsen - 11/88
055 FOS Polarimetry - R.G. Allen & P.S. Smith - 11/88
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057 Image Drift After HV Turn-on - W. Baity & E. Beaver - 2/89
058 Scattered Red Light in the FOS - W. P. Blair, A.f. Davidsen, & A. Uomoto 3/89
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060 FOS Filter-Grating Wheel Repeatability: Dependence on Motor Selection, G. Hartig - 5/89
061 FOS Optical Focus and Resolution - T. Ed Smith & G. Hartig - 10/89
062 Long Term FOS Calibration Plan - A.L. Kinney & G.F. Hartig - 8/89
063 FOS Project Data Base Aperture Files - A.L. Kinney & C. Cox - 10/89
064 FOS Dead and Noisy Channel Update - R. Cohen & E. Beaver - 10/89
065 The Rotation Matrix for Calculating V2, V3 Offsets in Mode 2 FOS TA - A.L. Kinney and G. Hartig - 3/90
066 Sensitivity of FOS Red Digicon to the External B-Fields - V. Junkkarinen, E. Beaver, R. Cohen and R. Lyons - Aug. 1990
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069 FOS Red Detector Flat-field and Sensitivity Degradation, G. Hartig - 11/91
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072 Aperture Calibrations During Science Verification of the FOS L. Dressel and R. Harms - May 1992 (reworked)

073 Scattered Light Characteristics of the HST FOS F. Bartko, G.S. Burks, G. A. Kriss, A.F. Davidsen, R.D. Cohen, V.T. Junkkarinen and R. Lyons - April 1992

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075 FOS Spectral Flat Field Calibration (Science Verification Phase Data), S.F. Anderson - February 1992

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078 FOS Polarimetry Calibration [update of CAL/FOS 055] R.G. Allen and P.S. Smith - March 1992

079 FOS Operation in the South Atlantic Anomaly W. A. Baity, E. A. Beaver, J.B. Linsky and R. W. Lyons - April 1992

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005 Procedure Used for Testing RSDP Algorithms - R.L. White - 12/87

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92-04 WF/PC Measles Contamination and Compensation with Delta Flats
92-05 A Library of Observed WF/PC Point Spread Functions
92-06 WF/PC EARTH-CALIB Exposure Times
92-07 WF/PC UV Calibration Following Decontamination

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02 Simulation of HST Point Spread Function, H. Hasan, 7/90
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4.8 Target Acquisition

001 Some Consideration on the Effect of the Determination of the HST Position Angle for "Complex" Target Acquisition - R. Gilmozzi, Dec 1988.

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2-01 WFPC-2 Science Capability Report, David I. Brown, 1/3/92

5. CALIBRATION STANDARDS

5.1 Bibliography

The astronomical standards that provide the basis for the HST calibrations are listed in the following series of 6 STScI internal documents that can be obtained from R. Bohlin.

STANDARD ASTRONOMICAL SOURCES FOR HST:

1. UV SPECTROPHOTOMETRIC STANDARDS, Bohlin, Blades, Holm, Savage, and Turnshek 87 Mar.

2. OPTICAL CALIBRATION TARGETS, Turnshek, Baum, Bohlin, Dolan, Horne, Koornneef, Oke, and Williamson 89 Jan.

3. STANDARD STARS AND NEBULAE FOR EXTERNAL WAVELENGTH CALIBRATION, Ford, Hobbs, and York 84 Aug.

4. ASTROMETRIC STANDARD FIELDS, Fresneau, Bohlin, Hemenway, Marsden, and van Altena 86 Jul.

5. POLARIMETRIC STANDARDS, Lupie, Stockman, Allen, Code, Dolan, Turnshek, and White 85 Oct.

6. SPATIALLY FLAT FIELDS, Cox, Bohlin, Griffiths, and Kelsall 87 Dec.

Additional publications that are relevant to the HST calibration are:

THE UV CALIBRATION OF THE HST IV. ABSOLUTE IUE FLUXES OF HST STANDARD STARS, R. Bohlin, A. Harris, A. Holm, and C. Gry 1990,

AP.J.SUPPL.,73,413.

AN ATLAS OF HST PHOTOMETRIC, SPECTROPHOTOMETRIC, AND POLARIMETRIC CALIBRATION OBJECTS, D. Turnshek, R. Bohlin, R. Williamson, Lupie, O., J. Koornneef, and D. Morgan 1990, A.J.,99,1243.

FAINT SPECTROPHOTOMETRIC STARS, J. B. OKE 1990, A. J., 99, 1621.

THE HST NORTHERN-HEMISPHERE GRID OF STELLAR POLARIMETRIC STANDARDS, G. Schmidt, R. Elston, and O. Lupie 1992, A. J., in press.

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THE ASTROMETRIC CALIBRATION OF THE HUBBLE SPACE TELESCOPE FINE GUIDANCE SENSORS, L. G. Taff 1990, Ap. J., 365, 407-418.

AN ANALYSIS OF THE HUBBLE SPACE TELESCOPE FINE GUIDANCE SENSOR COARSE TRACK MODE, L. G. Taff 1990, Experimental Astr., 1, 237-266.

BINARY STAR OBSERVATIONS WITH THE HUBBLE SPACE TELESCOPE FINE GUIDANCE SENSORS II. Bright Hyades, O. G. Franz, L. H. Wasserman, E. Nelan, M. G. Lattanzi, B. Bucciarelli, and L. G. Taff 1992, A. J., 103, 190-196.

AN ANALYSIS OF THE HUBBLE SPACE TELESCOPE FINE GUIDANCE SENSOR FINE LOCK MODE, L. G. Taff 1992, P.A.S.P., in press.

POST-PROCESSING OF RELATIVE ASTROMETRIC DATA, L. G. Taff 1992, submitted to the Ap. J.

THE HST SPECIAL ISSUES OF THE AP. J. LETT. in 1991: vol 369, L21-L78 and vol 377, L1-L64.

5.2 Calibration Data Base System (CDBS)

All of the astronomical reference data for HST calibration is entered in the CDBS, which is on line at the STScI. See the HST Cycle 1 Calibration Plan for hints on how to extract data from CDBS, if you have an account on an STScI machine; or contact the User Support Branch. Normally, the observational data is stored on SCIVAX::DISK$REFERENCE:[CDBSDATA.REFER.CALOBS]. Our primary spectrophotometic standards are patched together from the Bohlin et al. (1990) and the Oke (1990) spectra and stored in IRAF table format on SCIVAX::DISK$REFERENCE:[CDBSDATA.REFER.CALSPEC]. Version of these CALSPEC data have appeared on STEIS from time to time. Voyager data are used to extend these spectra shortward of the IUE cutoff at 1155A. Model atmosphere spectra are used to fill gaps and extrapolate from the typical Oke cutoff near 8000A to 12000A.

Since the creation of these CALSPEC files in 1989, a few problems have been discovered with the CALSPEC data base. First, the fluxes around the IUE cutoff at 1155A were not correct and caused trouble with the FOS and GHRS absolute calibrations. On 91Aug1, a new delivery of 18 stars to CALSPEC are corrected for this problem as detailed in the following table.

AGK_81D266
  Model replaced with Voyager data
BD_28D4211
  Model replaced with Voyager data
  Voyager data scaled by 0.96 to match 1160 to 1190 IUE flux
BD_75D325
  Model replaced with Voyager data
  Voyager data scaled by 0.80 to match 1150 to 1200 IUE flux
ETA-UMA
  Voyager data scaled by 0.90 to match 1150 to 1165 IUE flux
FEIGE110
  Model replaced with Voyager data
FEIGE34
  Model replaced with Voyager data
G191B2B
  Model replaced with Voyager data
  Voyager data scaled by 0.89
GD108
  Model data scaled by 1.26 to match 1157 to 1168 IUE flux
GRW_70D5824
  IUE cutoff changed to 1230.0
HD49798
  Model replaced with Voyager data
HD60753
  Model data scaled by 1.34 to match 1156 to 1167 IUE flux
HD93521
  Model replaced with Voyager data
  Last 2 Voyager points before IUE cutoff deleted
HZ21
  Model data scaled by 0.80
HZ44
  Model replaced with Voyager data
LDS749B
  Model data scaled by 1.16 to match 1250 to 1260 IUE flux IUE cutoff changed to 1250.0
MU-COL
  Model replaced with Voyager data Last Voyager point before IUE cutoff deleted
NGC7293
  Changed IUE/VOYAGER splice point to 1155.0.

Deleted Model data shortward of the Voyager data.

ZETA-CAS

OAO data replaced with IUE data

Last Voyager point before IUE cutoff deleted

A second problem is that the 4% lowering of his fluxes that is recommended by Oke (1990) was not incorporated in the CALSPEC composites, except for HZ44. The OKE flux values have been lowered by the 4% in the CALOBS data sets, and we are in the process of propagating this correction to 13 of the composite spectra in CALSPEC. The 4% change has been included in the data sets that are used to calibrate the FOS.

The relative spectrophotometry from the HST spectrographs should be more precise than the IUE, ground based, and model data that is incorporated in the CALSPEC files. As a long term goal, the composite spectra in CALSPEC can be improved by HST data. Already, FOS data have demonstrated that the ground based spectrophotometry for BD+33D2642 is low with respect to the other stars by about 5%. Another possible change is to convert to the white dwarf absolute flux scale, as is being done by the IUE project.

APPENDIX: Summary of the Major Steps in the Routine Pipeline Data Processing

The Routine Science Data Processing (RSDP) pipeline performs a number of basic calibration steps on the generically edited telemetry data. All steps are not performed in every case, because some are specific to certain instrument modes. Each step may be selectively excluded by setting initial calibration switches. A brief summary of the processes for each instrument follows. See the SI handbooks and the STSDAS Calibration Guide for more details.

FAINT OBJECT CAMERA

1) Subtract dark counts.

2) Perform a format-dependent photometric correction.

3) Split "zoomed" pixels.

4) Compute absolute sensitivity.

5) Correct for geometric distortion.

6) Correct for relative detector efficiency, i.e. apply a flat field.

FAINT OBJECT SPECTROGRAPH

1) Convert from raw counts to count rates. Disabled diodes are accounted for in this step.

2) Correct for the image displacement caused by the earth's magnetic field that is known as the GIM (Geomagnetically Induced Motion of the image).

3) Correct the count rates for saturation effects.

4) Subtract dark counts from both sky and object spectra. Interpolate across pixels missing because of data drop-out. There is an option to scale the background to make the mean count rate equal to a predicted count rate.

5 If the reference dark count rate is used in step 4, scale according to the geomagnetic position at the time of observation.

6) Apply a spectral flat-field correction. For paired apertures or spectropolarimetry observations, two flat fields are used.

7) Subtract the sky spectrum from the object spectrum. Includes smoothing and scaling by aperture area.

8) Compute vacuum wavelength scale for each spectrum.

9) Convert to absolute flux by multiplying by the inverse sensitivity factor.

10) Compute the propagated error for each point in the spectrum.

11) Perform corrections for the non-standard modes: time-resolved, spectropolarimetry, and rapid readout.

GODDARD HIGH RESOLUTION SPECTROGRAPH

1) Apply a data quality mask to the image in order to ignore the data in bad pixels.

2) Divide by the exposure time to get count rates.

3) Correct for the sensitivity of individual diodes.

4) Correct raw rates for saturation, or rate dependent efficiency.

5) Perform mapping. Relate sample and line values to photocathode position.

6) Remove the effect of photocathode non-uniformity by dividing by the photo-cathode response function.

7) Remove the effect of vignetting and wavelength dependent photocathode variations. (A Doppler correction may be applied while performing steps 6 and 7).

8) Merge sub-step bins

9) Apply a median, mean, and polynomial filters to the background measurements.

10) Subtract background and correct for scattered light.

11) Convert sample positions to wavelength using dispersion constants.

12) Adjust the zero point of the wavelength scale for the large science aperture and the spectral lamp aperture.

13) If an echelle grating is used, divide out the effect of echelle ripple.

14) Calculate the absolute flux.

15) Convert wavelengths to heliocentric coordinate system.

HIGH SPEED PHOTOMETER

1) Subtract current-to-voltage converter offset (analog data only).

2) Subtract dark current and pre-amplifier noise.

3) Correct for non-linearity caused by dead time (digital data only).

4) Apply gain factor (analog only).

5) Apply high voltage factor

6) Correct for relative sensitivity.

7) Convert to count rate

8) For extended targets only, divide count rates by the aperture area.

WIDE FIELD AND PLANETARY CAMERA

1) Perform the analog to digital correction. The correction depends on the value of BAY3TEMP.

2) Subtract the bias level

3) Subtract a scaled preflash image, the scaling depending on the preflash lamp exposure time.

4) Subtract the dark image, scaled to exposure time.

5) Multiply by the inverse flat field image.
6) Create a Data Quality File, flagging saturated pixels and data drop-out positions.

7) Create histograms of the input image, the A-to-D corrected image, and the fully calibrated image.

FINE GUIDANCE SENSOR

The RSDP pipeline does not currently process FGS observations. Prototype software exists in IRAF to perform the following operations.

1) Create data quality mask file(s) for FGS data file(s).

2) Remove particle events from FGS photomultiplier counts

3) Correct dead-time and remove dark from FGS PMT counts.

4) Compute occurrence times of FGS astrometry data.

5) Correct errors in FGS star selector encoder data.

6) Add or remove aberration from a data table

7) Add or remove mirror distortion from a data table.

8) Compute average rectangular coordinates and observation time.

9) First approximation of double-star parameters.

10) Convert coordinates from Equatorial to Spacecraft

11) Convert coordinates from Gnomonic to Spacecraft.

12) Convert coordinates from Pickle to Spacecraft.

13) Convert coordinates from Spacecraft to Equatorial.

14) Convert coordinates from Spacecraft to Gnomonic.

15) Convert coordinates from Spacecraft to Pickle.